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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

Report on Occupational Safety and Health for FY 1982

under Public Law 91-596

1982

NIOSH REPORT ON OCCUPATIONAL SAFETY AND HEALTH FOR FISCAL YEAR 1982 UNDER PUBLIC LAW 91-596

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

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I

		Page
I.	Introduction	
	A. Mission	1
	B. Priorities	2
II.	Research in Occupational Lung Disease	
	A. National Coal Study	4
	B. Short-Term Spirometric Study of New Coal Miners	5
	C. Insulating Materials - Fibrous Glass	6
	D. Short Asbestos Fibers	6
	E. Pathologic Standards for Asbestosis	6
	F. Use of Diesel Engines in Underground Mines	6
	G. Immunologic Aspects of Work-Related Respiratory Disease	
	1. Fibrous Minerals and Metals and the Interferon System	7
	2. Effect of Mycotoxins on Pulmonary Macrophages	8
	3. Washed Cotton	9
	4. Immunology of Grain and Other Organic Dusts	9
	H. Formaldehyde	10
III.	Research in Musculoskeletal Injuries	
	A. Ergonomic Analysis of Upper-Extremity Disorders	11
	B. Vibration Syndrome	11
	C. Effects of Exposure to Hot and Cold Work Environments	12
IV.	Research in Occupational Cancer	
	A. Pulp and Paper Industry	13
	B. Exposure to N-nitrosamines	13
	C. Registry of Dioxin Workers	14
	D. Organic Oxides	14
	E. Postal Cancellation Ink	14
	F. Gastric Cancer and Coal Mine Dust Exposure	15
	G. Workers Exposed to Toluene	15
	H. Workers Exposed to Styrene	16
	I. Wood Die and Model Makers	16
	J. Azo Dyes	17
V.	Research in Other Leading Work-Related Diseases and Injuries	
	A. Fractures, Amputations, Eye Losses, Lacerations, and Traumatic Deaths	
	1. Self-Tripping Power Presses	18
	2. Machine Safeguard Systems	18
	3. Video Display Terminals	19
	B. Cardiovascular Diseases	
	1. Carbon Monoxide	19
	2. Nitroglycerin	19
	C. Reproductive Problems	
	1. Reproductive Toxicology	20
	2. Effect of PCB's on Reproductive Outcome	20
	3. Effects of Exposure to Carbon Disulfide	21

		Page
D.	Neurotoxic Illness	
1.	Neurobehavioral Toxicology: Spray Paint Solvents	21
2.	Neurobehavioral Effects of Carbon Disulfide	22
E.	Noise-Induced Hearing Loss	
1.	Occupational Impulse Noise	22
2.	Personal Hearing Protection Devices	22
F.	Psychological Disorders	
1.	Machine-Paced Work and Stress	23
2.	Stress Reduction	23
VI.	Surveillance	
A.	National Occupational Exposure Survey	24
B.	National Electronic Injury Surveillance System	24
C.	Case-Comparison Study of Maternal Employment and Fetal Outcome	25
D.	Parental Employment and Spontaneous Abortion	25
E.	Blue-Collar Workers	26
F.	Cooperative Projects	26
G.	Accident Investigation Program	27
H.	Registry-based Occupational Cancer Surveillance - Phase I	27
VII.	Control	
A.	Safety Recommendations	
1.	Precast Concrete Products	28
2.	Oil and Gas Well Drilling	28
3.	Fabricated Structural Metal Industry	28
B.	Respirators	
1.	Testing and Certification of Respirators	29
2.	Respirator Research - Ergonomics	29
3.	In-Respirator Mask Monitor	30
4.	Field Evaluation of Powered Air-Purifying Respirators	30
5.	Lead Aerosol Penetration Study	31
C.	Particulate Control Research - Snagging Grinders	31
D.	Push-Pull Ventilation Techniques	31
E.	Analytical Methods	
1.	Inorganic Methods Development	32
2.	Study of New Laboratory Techniques	32
3.	Portable Gas Analyzers	33
4.	Dust-Measuring Instruments	33
VIII.	Health Hazard Evaluations	35
IX.	Training and Workforce Development	
A.	Educational Resource Centers	37
B.	Continuing Education	37
X.	Policy Statements and Documents	39
XI.	Superfund	40
	References	41

I. Introduction

A. Mission

Work-related illnesses, injuries, and deaths have both an immediate and a long-range impact on the safety and health of people in the United States. In 1970, Congress addressed this problem by passing the Occupational Safety and Health Act. This Act declares Congress' intention "to assure so far as possible every working man and woman in the Nation safe and healthful working conditions." The Act establishes the National Institute for Occupational Safety and Health (NIOSH), whose responsibilities include:

> ". . . providing for research in the field of occupational safety and health, including the psychological factors involved, and developing innovative methods, techniques, and approaches for dealing with occupational safety and health problems; exploring ways to discover latent disease [and] establishing causal connections between disease and work in environmental conditions."

Occupational exposures to hazardous physical and chemical agents pose an important and largely preventable threat to the health and safety of workers in the United States. Daily exposures to such hazards as asbestos, benzene, ionizing radiation, formaldehyde, silica, coal mine dust, lead, noise, excessive stress, and inadequately guarded machinery can result in a number of health problems, including cancers, chronic diseases of the heart and lungs, sterility, birth defects, peripheral neuropathies, deafness, psychological impairments, dermatitis, loss of eyes, and amputations. An estimated 7 million American workers are exposed to trade name products containing at least one toxic substance regulated by the Occupational Safety and Health Administration (OSHA) (1). Moreover, certain work situations result in biomechanical stress that can cause injuries to the musculoskeletal system; the effects of psychological stress on employees are also being investigated by NIOSH researchers.

NIOSH, a component of the Centers for Disease Control (CDC), is the lead Federal organization engaged in research in the National effort to protect the health and safety of America's workforce and to eliminate on-the-job hazards. The Occupational Safety and Health Act of 1970 (P.L. 91-596) and the Federal Mine Safety and Health Act (P.L. 95-164) specifically charge NIOSH to identify occupational safety and health hazards and to conduct research and workforce training in all aspects of work-related safety and health. NIOSH is responsible for recommending safety and health standards to OSHA and health standards to the Mine Safety and Health Administration (MSHA), agencies that set and enforce Federal standards to assure safe and healthful workplaces. NIOSH also has specific authorities under the Clean Air Act, Toxic Substances Control Act, Outer Continental Shelf Lands Act, and the Comprehensive Environmental Response, Compensation, and Liability Act. Additionally, NIOSH has general authorities under the Public Health Service Act.

B. Priorities

In an effort to provide a prevention-oriented framework for the Institute's stewardship of its mission, in 1982 senior scientists of the Institute developed a list of the 10 leading work-related diseases and injuries. The list was compiled using an iterative technique (2). These experts developed ranked lists of what they regarded, on the basis of their knowledge, training, and experience, to be the most important health problems associated with work. They considered three criteria in developing the list: the known or suspected frequency of occurrence of the disease or injury, its severity in the individual case, and its amenability to prevention. The resulting list (Table) includes examples of specific conditions in each ranked category.

The purpose of the suggested list of leading work-related diseases and injuries is fourfold: 1) to encourage deliberation and debate among professionals in the field concerning appropriate National priorities in this important area of public health, 2) to assist in setting priorities for the control of health problems related to work, 3) to assist in planning the programs and research of the Institute, and 4) to convey to a diverse audience the focus and direction of the programs of NIOSH.

The list is intended to be dynamic; it will be reviewed and updated periodically as knowledge increases and as conditions change in frequency and are brought under better control. Small groups of the Institute's staff will be assigned to study each of the 10 problem areas in depth, to refine estimates of the magnitude of each problem, and to formulate detailed strategies for prevention. In addressing these problems, the Institute seeks to work with all the aspects of the public health structure of the Nation, as other parts of CDC have done to foster control of the other preventable health problems.

The list has become part of the Institute's priority system, which identifies: 1) subjects warranting documentation of occupational safety and health hazards and issuance of guidelines or formal recommendations (e.g., for standards recommended to OSHA and MSHA), and 2) priorities for research designed to provide information for more complete hazard assessment or for hazard control. These goals are accomplished by integrating the scientific knowledge gained from the Current Awareness System for chemical and physical agents with the knowledge gained through the injury and illness surveillance programs of the Institute. Thus, the priority system serves as an instrument for devising strategies to prevent the Ten Leading Work-Related Diseases and Injuries.

The Ten Leading Work-Related Diseases and Injuries
United States, 1982*

#1 Occupational Diseases of the Lung
Lung cancer, silicosis, asbestosis, coal workers' pneumoconiosis, byssinosis, occupational asthma

#2 Musculoskeletal Injuries
Disorders of the back and trunk, upper extremities and neck, lower extremities; traumatically induced vibration syndrome

#3 Occupational Cancers (other than lung cancer)
Leukemia, mesothelioma, cancers of the bladder, nose, and liver

#4 Amputations, Fractures, Eye Loss, Lacerations, and Traumatic Deaths

#5 Cardiovascular Diseases
Hypertension, coronary artery disease, acute myocardial infarction

#6 Disorders of Reproduction
Spontaneous abortion, infertility, teratogenesis

#7 Neurotoxic Disorders
Peripheral neuropathy, toxic encephalitis, psychoses, extreme personality changes (related to exposures)

#8 Noise-Induced Loss of Hearing

#9 Dermatologic Conditions
Dermatoses, burns (scaldings), chemical burns, contusions (abrasions), lacerations

#10 Psychological Disorders
Neuroses, personality disorders, alcoholism, drug dependency

*The conditions listed under each category are to be viewed as <u>selected examples</u>, not comprehensive definitions of the category.

This annual report will describe research projects that address the problems on the list of the 10 leading work-related diseases and injuries. The report, like the Institute's research, focuses mainly on the problems of top priority and on the programs designed to identify and control them. It covers only the highlights of NIOSH activities during Fiscal Year 1982; it is not intended to be all inclusive, but instead to represent the Institute's accomplishments and progress toward goals.

II. Research in Occupational Lung Disease

The lung is both a target organ and a portal of entry for toxic substances. The likelihood of toxic exposure is high; for example, an estimated 1.2 million workers each year are potentially exposed to silica dust alone (3). Work-related lung disease may be difficult to recognize, because the latency period for these diseases may be quite long--as long as 15 years for silicosis and 30 years or more for asbestos-related diseases. In addition, other factors such as cigarette smoking play an important role and can obscure the association between work and the disease (4). Examples of important occupational lung diseases are lung cancer, asbestosis, silicosis, coal workers' pneumoconiosis, byssinosis, and occupational asthma. Each of these conditions is preventable, although years of effective control measures will be required before those diseases of long latency can be eliminated. The rapidity with which new agents are being introduced into the worksite further complicates the task of prevention.

A. National Coal Study - Two projects deal with questions of dose response and the adequacy of the MSHA coal mine dust standard of 2 mg/m^3:

(a) NIOSH has recently completed the third round of the National Coal Study (NCS), a longitudinal epidemiologic survey of U.S. underground coal workers. The overall prevalence of coal workers' pneumoconiosis (CWP) in the third round was 5%; this pattern of results was somewhat reduced from that seen in rounds 1 and 2. NIOSH is examining the incidence and progression of CWP among miners who participated in both the first and third rounds. An advantage of this long-term study will be the follow-up of former miners, which should eliminate any "healthy worker effect." This form of bias is caused in part by the tendency of workers who become ill to leave the workforce, so that the group of workers remaining to be studied is made up of those possibly less susceptible to disease.

(b) NIOSH has also analyzed surveillance data collected as part of the scheme for regular X-rays of miners authorized under the 1969 Coal Mine Health and Safety Act. The surveillance was initiated in order to identify cases of CWP and offer miners thus identified the right to transfer to a less dusty area of the mine.

On a larger scale, both these studies are concerned with the prevalence and incidence of CWP and its relationship to dust. In both cases, groups of miners have been followed for about 10 years, and the miners' X-rays are being read for pneumoconiosis. The results should provide information on dose response and on whether the current standard is adequate. The NCS will also provide information about other diseases, such as bronchitis, and their

relationship to dust exposure.

The maximum dust exposure allowed for underground coal miners in the United States is 2 mg/m^3. This standard was based on information obtained primarily in the United Kingdom, and it is not known to what extent extrapolation of these data is valid for U.S. coal miners. NIOSH has undertaken more than 10 projects addressing this problem and other questions involving the respiratory health of miners. NIOSH is also conducting two important studies of coal miners that relate to the selection of miners into and out of mining and thus will also shed further light on the question of the healthy worker effect. One of these studies, which involved an indirect comparison of current with former miners, has indicated that the health of the latter group may be somewhat worse than that of continuing miners. Another study, which is described below, revealed no obvious selection effects nor any marked acute changes in these early years of work in the mine.

B. Short-Term Prospective Spirometric Study of New Coal Miners - During this study, NIOSH investigators used questionnaires and spirometry to examine prospectively a small cohort of 116 new coal miners. Data collection began just before the workers began their employment underground and continued at 6-month intervals over a 2-year period. The study is designed to address the question of short-term adverse pulmonary effects and their relationship to miners' outward migration from the industry. Lung function tests were administered when the miner first began to work in the mines and were repeated at 6 months. The tests results at the beginning and end of the work shift were compared so that any acute effect due to dust, which might be related to chronic decline in lung function, could be detected.

The results of the shift study at 6 months revealed a slight but statistically significant decrement in lung function (a 1.9% drop in forced expiratory volume in 1 second (FEV_1), $p \leq .01$) over the work shift. In addition, miners who exhibited a decrement in FEV_1 greater than 5% at 6 months also exhibited accelerated annual decrements in lung function over the 2-year period (a decrement in FEV_1 of 179 ml/year).

NIOSH observed substantial intra-subject variability in this short-term longitudinal study, which suggests that short-term annual examinations of pulmonary function over only a few years may be of limited practical value for detecting small decrements in lung function in individual miners. The annual decrements in lung function in the new miners appeared to be linear with respect to length of employment and exposure to coal mine dust. No marked initial drop in lung function was observed, suggesting that the cross-sectional and follow-up studies of working miners in the NCS should give accurate estimates for new as well as for experienced miners. In addition, there was no evidence of bias in these results caused by miners leaving the study for occupational medical reasons.

A statistically significant increase in symptoms of bronchitis (8 of 89 miners) occurred at the 24-month examination. This relatively late onset of bronchitis is also consistent with findings of the NCS. The short-term study, in addition to providing evidence for the validity of the NCS, enabled NIOSH to conclude that studies over the work shift can be useful for identifying the

workers who are most susceptible to respiratory disease.

C. Insulating Materials - Fibrous Glass - Previous animal studies have alarmed health scientists about the carcinogenicity and fibrogenicity of inhaled particles. These studies have indicated that particle geometry, rather than chemical composition, is a primary factor in producing toxicity. All previous studies, however, produced cancer or fibrosis by instilling fibers into the animal without consideration of respirability and aerodynamic factors. In 1982 NIOSH completed a long-term study of the effects of fibrous glass, in which short glass insulation fibers (10 um), long fibers (|20 um), small-diameter fibers (3.5 um), and large-diameter fibers (4-6 um) were inhaled. No evidence of pulmonary fibrotic or carcinogenic responses was found, lessening concern that fibrous glass may produce the same response as asbestos fibers. The Institute results, based on lifelong exposure in rodents, appear to indicate that fibrous glass does not have the devastating toxic and carcinogenic effects of asbestos.

D. Short Asbestos Fibers - NIOSH completed a report on the carcinogenicity of short (5 um in length) asbestos fibers. At the end of the 2-year study period, the lung tissues of the exposed subjects were examined by both light and electron microscopy. Asbestos fibers were identified in the lung tissue, but no fibrosis, lung tumors, or other lesions were present. The histochemical data on both crysotile-exposed and control groups showed no significant differences between groups.

Asbestos fibers shorter than 5 um in length are generally considered to be much less harmful than longer fibers; they have been classified by OSHA as nuisance dusts and have been assigned a health standard of 5 mg/m^3. The results of this study do not indicate that a stricter standard is needed. The cocarcinogenic effects of short asbestos fibers, however, still need to be determined.

E. Pathologic Standards for Asbestosis - The Institute has completed a 2-year project designed to develop 1) criteria for the pathologic diagnosis of pleuro-pulmonary disease associated with asbestos and 2) a method for grading the severity of asbestosis. Surgical and autopsy material was collected worldwide and reviewed by an expert committee of pulmonary pathologists, assembled under the aegis of the College of American Pathologists. A series of cases from the files of the Armed Forces Institute of Pathology was graded according to a scale developed by the committee.

No formal criteria had heretofore existed for defining asbestosis. Not only has a minimal definition of asbestosis now been established for diagnostic purposes, it has also been demonstrated that biopsy and autopsy materials collected worldwide are similar. The new standards will enable more accurate diagnoses of asbestos-associated diseases, help in establishing industrial compensation claims, and allow better epidemiologic studies and studies involving correlation of radiologic and physiologic parameters with underlying pathologic anatomy.

F. Use of Diesel Engines in Underground Mines - Diesel-powered equipment and transport are being used increasingly in both coal and other mines (and on

the roads of the United States). It is therefore important that an understanding be gained of the health effects of exposure to the exhaust. The use of diesel engines offers advantages to the mining industry, both in safety and economics. Diesel engines are predicted to be safer because they are less likely than gasoline engines to cause explosions. Because of their greater power, diesel engines are faster and can carry more payload, and therefore expose fewer personnel to the hazards of the mine. NIOSH has completed three aspects of a long-term study of the use of diesel engines in underground mines.

1. NIOSH analyzed both the acute (over an 8-hour work shift) and the chronic (over a 5-year period) effects of exposure to diesel emissions on the respiratory health of underground coal miners. This study revealed no evidence of adverse respiratory effects from exposure to diesel emissions at the levels found in mines.

2. NIOSH researchers investigated the effects of exposure to underground diesel emissions on the occupational mobility of coal miners. This study was designed to determine whether exposure to underground diesel fumes is a cause for persons to leave the workforce of a mine and if the mobility can be related to workers' prior state of respiratory health. The Institute found no evidence that mobility could be related to respiratory symptoms produced by exposure to diesel emissions.

3. The Institute studied the safety aspects of the use of diesels underground in U.S. coal mines. Since one argument in favor of the use of diesels underground is that they are inherently safer than other sources of power, NIOSH is examining the safety record of the last 5 years of experience with diesel engines in all U.S. underground coal mines.

NIOSH has also been investigating the health effects of exposure to diesel exhaust in several groups of underground mineral mines. Epidemiologic investigations have been undertaken in rock salt, potash, and trona mines. The advantage of examining workers in these mines is that the background mineral in each case is regarded as a nuisance dust, not as a great health hazard. Any adverse respiratory effect, therefore, may be assumed to be a result of the exposure to diesel emissions at the levels found in mines.

NIOSH studies have generally shown that symptom levels among the miners were elevated, although no clear-cut patterns of dose-response with diesel exhaust have emerged. In the group of trona miners, an unusually large decline in lung function with age was noted, though responsibility for this could be assigned neither to the diesel exposure nor the dust exposure.

G. Immunologic Aspects of Work-Related Respiratory Disease - As part of the Institute's program aimed at preventing occupational lung disease, several research projects have examined the natural defense systems of the lung and ways in which these barriers against disease are affected by occupational exposures.

1. Fibrous Minerals and Metals and the Interferon System - The interferon system is a primary host defensive mechanism against viral

infectious agents, is highly sensitive to potential carcinogenic agents and toxic chemicals, and may be involved in the pathogenesis of dust diseases. Various particulate matter associated with occupationally related dust diseases were investigated for their effect on the interferon system. Of the particulates tested, asbestos, coal dust, diesel exhaust emissions, lignite, fly ash, organic and inorganic soluble components from fly ash matrix, and chromium and manganese metals all significantly inhibited the viral induction of interferon. By measuring the inhibition of viral activity, researchers are able to gauge the amount of interferon produced in the presence of these materials. NIOSH researchers have been the forerunners of this type of interferon study.

An association was revealed between interferon production and coal rank. (The prevalence of coal workers' pneumoconiosis is associated with coal of high rank, that is, older coal of higher carbon content, such as anthracite and bituminous). High-rank coal depressed interferon production; low-rank coal was progressively less antagonistic. In the presence of the particulates mentioned above, levels of influenza virus growth were higher than in controls. This observation was associated with depressed interferon production. In contrast, wollastonite, a substance being widely used as a substitute for asbestos, was found to enhance interferon growth. This Institute finding lessens concern about the safety of wollastonite in these applications and also points to its potential use in the production of interferon for medical use.

On a basic research level, this study addressed several occupationally related dusts to which workers are exposed and established a role of the interferon system in the pathogenesis of associated diseases and in the alteration of the susceptibility of the host to viral agents. The sensitivity the interferon system exhibited with a variety of occupationally related dusts and chemical agents of known disease potential demonstrated its usefulness for bioassay, research, surveillance, and prevention purposes.

2. Effect of Mycotoxins on Pulmonary Macrophages - Another natural defense mechanism of the lung is the alveolar macrophage, a cell that ingests invading microorganisms or other cells and foreign particles. NIOSH studies with alveolar macrophages have demonstrated that exposure to T-2 toxin (one of the mycotoxins, toxins of fungous or bacterial origin) at submicromolar concentrations causes a decrease in cell viability, cell numbers, and cell volume. Exposure to T-2 toxin also inhibits phagocytosis, the process in which the macrophage engulfs and destroys foreign particles. These studies have also shown that T-2 toxin blocks macrophage activation. Additional NIOSH mycotoxin studies have shown that secalonic acid D, another mycotoxin, is acutely toxic in rat lungs, causing acute inflammation and damage to the distal airway and adjacent alveoli at doses far below the reported LD_{50} values.

These studies will lead to greater public and professional awareness of the potential hazard these mycotoxins represent and will aid in the development of measures designed to reduce exposure. Since mycotoxins can potentially occur in the diet in meat and cheeses, as well as in grains, it may be relevant to consider the combined effects of mycotoxins with synthetic

toxic agents to which workers are exposed.

3. Washed Cotton - Another area of research involving the lung's natural defenses is directed toward byssinosis, a lung disease associated with the cotton industry and caused by the inhalation of cotton dust. In 1978, to reduce the prevalence of byssinosis, OSHA promulgated a strict standard for occupational exposure to cotton dust, which stressed engineering controls to limit dust concentrations in cotton mills. Large capital expenditures are required for compliance, and byssinosis can be expected to occur even at dust concentrations in compliance with the standard.

There is a great deal of interest in determining the causative agent for this disease. NIOSH is developing bioassays in order to gain more knowledge about the physiologic alterations associated with byssinosis. Researchers have studied the effects of rutin, catechin, and gossypol, three compounds found in the cotton plant, on the function of alveolar macrophages. These compounds were demonstrated to inhibit phagocytosis and the release of antibacterial substances from the alveolar macrophages; some of the compounds also inhibit the release of lysosomal enzymes, which digest ingested particles. These effects impair alveolar macrophage function, i.e., exposure of the cells to these compounds damages the defense system of the lung.

On the basis of information indicating that workers who are exposed to vigorously cleaned and washed (for example, medical grade) cotton do not suffer byssinosis symptoms and detrimental physiologic effects, OSHA has exempted "thoroughly washed" cotton from the standard. Such cotton, because it lacks natural lubricants, cannot be spun into quality yarn. In cooperation with industry, labor, and the Department of Agriculture, NIOSH is conducting research to determine whether less thorough washing (from a yarn production standpoint) is effective in removing the toxic agent(s) from cotton.

Data derived from this cooperative effort demonstrate that washing cotton in water (without boiling, alkali, or bleach and in the presence of a wetting agent) markedly reduces the acute bronchoconstrictor effect on workers who breathe the dust. Such attempts to define the causative agent(s) of byssinosis may lead to effective and economical approaches to preventing this disease.

4. Immunology of Grain and Other Organic Dusts - Other studies of the lung's defense system concentrated on organic dusts and the immunologic responses they produce in exposed workers. Occupational exposure to organic dusts is found in many jobs, most notably those associated with agriculture and animal husbandry. Institute scientists studied the mechanisms involved in macrophage processing of organic dusts and nonspecific activation of the immunologic events that lead to inflammation. NIOSH also monitored workplace dusts for the biologically active components called endotoxins. In the absence of a specific antibody, human complement, a substance in blood that attacks bacteria, is activated by grain dusts in vitro by pathways in addition to those previously documented. Grain dust thus has a greater potential for causing inflammation than had been suspected. These studies indicate that a worker does not have to become immunologically sensitized to organic dusts to suffer an inflammatory reaction, which points to a wide susceptibility in the

workforce.

Cotton dust also activates complement, and, in a study of human subjects in a model cardroom, NIOSH showed functional complement changes in vivo. Neither grain nor cotton dust activations were related to the gram-negative bacterial endotoxin levels in the dusts, so that the particular complement-active material must still be defined. Endotoxins, however, are extremely active materials. NIOSH research showed that they are present in high concentrations in animal confinement units and poultry processing plants. The endotoxin exposures in the model cotton cardroom, while not related to complement activation in vivo, were associated with changes in the pulmonary function of the subjects. Therefore two separate biologic events, complement activation and endotoxin exposure, are occurring, and both have distinct physiologic consequences. Also related to complement activation is the role of the alveolar macrophage in processing, transporting, and digesting organic dusts.

The biologic disease mechanisms, cellular events, and occupational level of the materials in dusts are all interrelated. Occupational exposures to the dusts and contaminants studied as well as the potential for immunologic reactivity can be expected in farming, grain handling, textile manufacturing, sewage treatment, composting operations, and animal husbandry, confinement, and processing. The worker population at risk is therefore large and diverse.

H. Formaldehyde - Formaldehyde has been used extensively in various manufacturing processes since the late 1940's. Resins, fertilizer, wood and paper products and textiles have been the major industrial uses of formaldehyde. An estimated 1.6 million workers are exposed to formaldehyde in more than 60 industrial categories. The Institute's study of formaldehyde was initiated in Fiscal Year 1980 in view of the findings reported by the Chemical Industry Institute of Toxicology that low levels of formaldehyde were carcinogenic in rats. This NIOSH research will fill some of the gaps in the literature and meet the research needs of characterizing exposures and determining the effects of exposures.

A literature review has been conducted, a cohort suitable for study has been identified, and quantification of exposure concentration ranges has been initiated. The garment manufacturing industry was selected for the mortality study because of the continuous low-level exposure, the quality of the record systems, the numbers of personnel exposed, and the length of exposure. Walk-through industrial hygiene surveys of a formaldehyde production facility, a mushroom growing operation, a textile finishing and printing plant, eight garment manufacturing plants, a peritoneal dialysis suite at a hospital, and a paraformaldehyde packaging operation have been conducted. Two of the garment manufacturing plants have been selected for inclusion in the mortality study. Follow-up studies for the plants have been initiated and in-depth industrial hygiene surveys have been conducted. After the industrial hygiene support of the cohort mortality study in garment workers is completed, NIOSH will collect environmental data from other types of occupational exposures, including plywood, paper products, particle board, and furniture manufacturing.

III. Research in Musculoskeletal Injuries

In 1982, musculoskeletal injuries accounted for 580,000 (18%) of the estimated 3.2 million occupational injuries treated in hospital emergency rooms in the United States (5). The physical demands of many work activities make the musculoskeletal system highly susceptible to a variety of occupational injuries and illnesses. Especially prominent factors in the development of these disorders are manual materials handling, repetitive motion, and vibration.

The potential exists for effective intervention in musculoskeletal injuries. The Institute is studying strategies for intervention, including: 1) substituting materials handling equipment (e.g., hoists, cranes, dollies) for manual transport of materials; 2) redesigning equipment to minimize vibration; 3) designing manual tasks to minimize biomechanical stress; 4) training workers to improve their tolerance for musculoskeletal stresses; and 5) altering work practices through such measures as job rotation. Highlights of the Institute's research in the area of musculoskeletal injuries are described below.

A. Ergonomic Analysis of Upper-Extremity Disorders - Ergonomics is a discipline that designs jobs to fit the capabilities of the worker. During 1982, NIOSH conducted ergonomic assessments of biomechanical hazards to the upper extremities of workers performing certain jobs at five worksites. Three such investigations took place in response to requests for health hazard evaluations at plants manufacturing electrical cords, fiberglass housings, and mechanical lubricating devices. The other two assessments focused on high-risk jobs in garment manufacturing and poultry processing operations, which will serve as candidates for demonstrating methods for intervention. The incidence rates for carpal tunnel syndrome and ganglionic cyst tendinitis found in these five evaluations ranged from four to twenty-eight cases per 100 person-years of work. Data collected by cinemagraphic and electromyographic methods identified work patterns involving repetitive, twisting hand movements and high forces in combination with awkward arm, wrist, or hand positions as risk factors in upper-extremity disorders. These results allowed NIOSH to suggest tool redesign, workstation layout, job rotation, and other procedures for hazard control. The information gathered from these and other investigations has been compiled into a hazard alert bulletin that will spur greater recognition of the biomechanical hazards of job tasks and associated disorders of the hand and wrist.

B. Vibration Syndrome - Approximately 1.2 million workers were exposed in 1974 to segmental vibration, an occupational hazard that causes vibration syndrome, which is characterized by numbness and blanching of the fingers with reduced sensitivity to heat, cold, and pain (6). The principal sources of segmental vibration are handheld power tools such as chain saws and jackhammers. The prevalence of vibration syndrome may reach 90% in certain groups of workers (7). Studies were completed and published on 385 vibration-exposed chipper and grinder workers and control workers at two

foundries and a shipyard. The findings indicated that the prevalence of vibration syndrome ranged from 19% in the shipyard to 47% in the foundries, with a mean latency of 16.5 years and 1.4 years, respectively. The Institute also evaluated the effectiveness of several new prototype antivibration tool designs and began a project designed to assess the antivibration characteristics, if any, of work gloves.

C. Effects of Exposure to Hot and Cold Work Environments - Numerous studies have investigated the acute effects of exposure to hot environments, which include heat stroke, heat exhaustion, and heat cramps. This project broadened the traditional approach of heat stress research by measuring the effects of hot and cool workplace conditions on safety-related behavior.

During a 14-month period, NIOSH investigators monitored workers' behavior and thermal exposure at two manufacturing plants. The study entailed over 17,000 observations of worker behaviors, such as using safety and personal protective devices and locking out electrical equipment before performing maintenance. The results showed that the proportion of safe behaviors is optimal when the workers were exposed to conditions in the thermally comfortable range of approximately 60° to 80° F. Conditions that were either hotter or colder resulted in a decreased proportion of safe behaviors.

In a related study, NIOSH evaluated workers' compensation data and gained new information about work-related injuries associated with exposure to hot and cold environments. The data were based on the 1979 claim experience of 30 States that participated in the Bureau of Labor Statistics' Supplementary Data System. The claims attributed to hot environments (e.g., heat stroke and heat exhaustion) were found to have the highest incidence ratios in the agriculture, construction, and mining industries; the occupations with the most claims were firemen and laborers. The claims attributed to cold environments, primarily frostbite, were found to have the largest incidence ratios in the mining, construction, agriculture, and transportation industries, while the occupations with the most claims were laborers, truck drivers, firemen, policemen, materials handlers, and garbage collectors. The total number of State workers' compensation claims for the United States in 1979, the most recent figures available, is estimated to be approximately 1,700 claims for heat exposure and 1,500 claims for cold exposure.

IV. Research in Occupational Cancer

A. Paper and Pulp Industry - An extensive retrospective cohort mortality study of paper and pulp workers was completed in Fiscal Year 1982. NIOSH investigated the mortality experience of 3,552 workers from several plants located in the Pacific Northwest. These workers, who were followed through the Social Security Administration and the Internal Revenue Service to discover their mortality status, had to have been employed in this industry for at least 1 year between 1945 and 1955. Although no etiologic agents could be distinguished, the findings suggest an increase in lymphatic disease, which is consistent with the findings of another investigation. The results indicate the need for further study to determine the adverse effects, if any, of exposure to wood dust, formaldehyde, sulfur compounds, and other chemicals in this group of workers.

In a related effort, a control technology assessment in the pulp and paper industry was completed in 1982. Although extensive process and environmental data are available, very little information pertinent to workplace exposure agents and their control had heretofore been available. The study, which was conducted in workplaces where good control technology was in use, documented that under these conditions routine exposures to toxic agents can be well controlled. Process operations and equipment, work practices, and personal protective equipment used in these mills were documented for the 40 operations observed. Area and personal sampling for chlorine, chlorine dioxide, airborne particulates, formaldehyde, sulfur dioxide, hydrogen sulfide, methyl mercaptan, and other organic sulfur species generally indicated exposures below NIOSH recommendations and substantially below OSHA regulations in well-controlled plants. Excessive exposure to these and other chemical agents used in or produced by pulp and paper-making processes is known to cause lung disease and dermatologic problems and is suspected to cause cancer and reproductive problems. The information obtained will therefore be useful in the establishment of hazard control plans for poorly controlled plants or operations in this and related industries. The study will also provide needed data for the incorporation of occupational safety and health control technologies in the design and engineering of such facilities while they are being constructed or modified.

B. Exposure to N-nitrosamines - A 4-year study to determine workers' exposure to N-nitrosamines in a variety of industries was completed in Fiscal Year 1982. This study involved 55 on-site environmental surveys conducted at 40 manufacturing facilities where there was evidence that workers were potentially exposed to N-nitroso compounds. The industries included were fish processing; manufacturers and users of synthetic metal working fluids; dye manufacturing; leather industry; rubber industry; soap, detergent and surfactant industry; and iron and steel casting industry. The highest levels of N-nitroso compounds were found in the rubber industry, where exposure to N-nitrosomorpholine was as high as 250 ug/M^3. Unidentified nitrosocompounds were found in the dye industry at levels up to 40 ug/M^3. N-nitrosodimethylamine, at levels as high as 47 ug/M^3, was detected in chrome leather tanneries. The levels of nitrosocompounds detected in the other industries surveyed ranged from 0.06 to 1.40 ug/M^3. Although there is no OSHA Permissible Exposure Limit for exposure to nitrosamines, experiments with

animals indicate that these compounds should be regarded as suspected carcinogens. Detectable levels of exposure to workers, therefore, indicate the potential for adverse effects.

C. Registry of Dioxin Workers - The objective of this ongoing project is to establish a registry of all workers in the United States who have been associated with the synthesis of the pesticide 2,4,5-T and other dioxin-contaminated substances. The registry, which includes work and exposure histories for all the workers registered, will be used initially for a retrospective cohort mortality study. The workers then will be followed prospectively. The registry will be evaluated to determine whether the cohorts can be utilized for studies of reproductive outcomes and morbidity. With assistance from a dermatologist, a subcohort of workers with diagnosed or probable chloracne, an exposure-associated skin condition resembling acne, will be identified for mortality analysis. A dermatologist has also studied a sample of medical records to evaluate how cases of chloracne might be identified and categorized.

For the initial retrospective cohort mortality study, workers are being traced historically through the Social Security Administration and other sources. The cause of death for deceased workers will be determined and coded from the death certificate. Rates by cause of death will be age- and sex-adjusted and compared with State and National rates. The workers' degree of exposure by number of years exposed and industrial process will be calculated. Registrants will be followed prospectively and reviewed with additional mortality studies. During October 1982, data collection was completed at five sites. Social Security follow-up has also been completed for these sites, and workers with unknown vital status are now being followed through the Internal Revenue Service.

D. Organic Oxides - NIOSH has concluded the in vivo phase of a chronic inhalation toxicity and carcinogenicity study of ethylene oxide (EtO), to which workers in the hospital and chemical industries are exposed. Researchers found treatment-related increases in the incidences of mononuclear cell leukemias, peritoneal mesotheliomas, and gliomas in rats exposed for 2 years to EtO at 50 or 100 ppm. The incidences of these tumors were not elevated after exposure to propylene oxide (PO) at 100 or 300 ppm for the same period. Analyses show a statistically significant dose-response increase in the incidence of sister chromatid exchanges (SCE's) and in chromosomal aberrations in the peripheral lymphocytes of animals exposed to EtO at 50 or 100 ppm. Animals exposed to PO at 100 or 300 ppm did not exhibit the differences in SCE's or chromosomal aberrations when compared with controls. Two parameters of reproductive capacity in males, mean sperm counts and mean sperm motility, were depressed after exposure to both EtO and PO. These findings indicate that EtO may be a potential human carcinogen and mutagen that in addition may produce adverse cytogenetic and reproductive effects.

E. Postal Cancellation Ink - At the request of the U.S. Postal Service, NIOSH studied the toxicity of an improved cancellation ink. Use of the permanent ink will result in savings for the Postal Service, as it cures on contact with cellulose and cannot be soaked off stamps to allow their re-use. An additional advantage is that the new ink is less likely to clog

cancellation machines than the oily ink formerly in use and will therefore lower maintenance costs.

The histopathology data indicated that the ink, although possessing some inherent toxicity at high doses, was not carcinogenic under the conditions of the study. The Institute approved the use of the new ink formulation, but recommended that Postal employees wear gloves and aprons to minimize skin contact with the ink. This project is an example of cooperation between government agencies that has resulted in significant savings to the taxpayer.

F. Gastric Cancer and Coal-Mine Dust Exposure - Gastric cancer excesses have been noted among coal miners both in the United States and abroad. A widely accepted explanation postulates that coal miners inhale the coal dust, and that it is then cleared and swallowed. Other factors, including occupational exposure to coal mine dust as well as cigarette smoke, may influence the rate of lung clearance and may be related to gastric cancer. NIOSH researchers studied gastric cancer in coal miners on the basis of information from death certificates, but the results could be of benefit to living miners.

This study has contributed to an understanding of the disease process by demonstrating that exposure to coal mine dust increases gastric cancer risk among long-term cigarette smokers. As a result of these findings, coordinated epidemiologic and laboratory research has been undertaken to examine the mutagenicity of coal dust. The preliminary laboratory study shows that nonmutagenic coal dust extracts can be nitrosated under an acidic condition (pH 3.2) to substances mutagenic for bacteria as well as human cells. Further studies on nitrosation of coal dust with nitrite and other exogenous factors and identification of nitrosated mutagenic constituents will be performed. These studies may provide an explanation of the elevated incidence of gastric cancer in coal miners.

G. Workers Exposed to Toluene - Toluene has received much attention recently because of the potential long-term health effects associated with occupational exposure. Both the Toxic Substances Control Act and the Chemical Industry Institute for Toxicology have listed toluene as a first priority for study. Toluene is a chemical of major use in U.S. industry today. In 1970, an estimated 694 million gallons of toluene were produced and approximately 100,000 workers were potentially exposed. In addition, toluene may be substituted for benzene in many industrial processes.

Investigators have noted that acute toxic properties of toluene include chromosome changes and effects on the nervous system, liver, and blood cells. Of specific interest, exposed workers have exhibited depressed erythrocytes, hepatomegaly, macrocytosis, and chromosome breaks and aberrations. Chromosome changes have also been noted in exposed rats.

The current OSHA standard is 200 ppm as an 8-hour time-weighted average, with an acceptable ceiling level of 300 ppm. Acceptable maximum peaks above the ceiling of 500 ppm are allowed for 10-minute durations. However, controlled exposure of human subjects to 200 ppm of toluene for 8 hours produced mild fatigue, weakness, contusion, lacrimation, and paresthesia.

Since chronic exposures may cause damaging effects, NIOSH has recommended a limit of 100 ppm (time-weighted) with a ceiling of 200 ppm for a 10-minute sampling period.

Two shoe manufacturing plants have been selected for study to determine if workers exposed to chronic levels of toluene have an increased risk of mortality. Microfilming of employment records and industrial hygiene sampling have been conducted in both plants. Demographic and work history information has been entered onto a computer file, and vital status follow-up has begun.

H. Workers Exposed to Styrene - Recent information indicates that workers exposed to styrene may experience chronic health problems, including increased risk of leukemia. To further evaluate the potential health effects of styrene, NIOSH is conducting a retrospective cohort mortality study and an industrial hygiene study of workers exposed to styrene. The cohort includes 5,272 men and women who were employed between 1957 and 1978 by two reinforced plastic boat-building companies in Washington State. In-depth industrial hygiene surveys have been conducted at seven reinforced plastic boat-building facilities, two of which were those used for the cohort mortality study.

The industrial hygiene surveys characterized the levels of styrene exposure within the industry, as well as evaluating the potential for other exposures. The mortality analysis will examine up to 89 death categories to determine if there are any excess mortality risks among this cohort. The mortality risk by level of styrene exposure within job categories will be evaluated.

I. Wood Die and Model Makers - A previous proportional mortality ratio study by NIOSH, conducted in response to a request for a health hazard evaluation, as well as studies by the Memorial Sloan-Kettering Cancer Center and the Michigan Cancer Foundaton, has indicated that excess morbidity and mortality due to colorectal cancer, leukemia, and other cancers exist among automotive wood workers.

To determine whether the excess mortality could be confirmed and whether the excesses actually could be related to occupational exposure, NIOSH began a retrospective cohort mortality study and an environmental assessment on about 2,500 automotive wood die and model makers who were employed at one facility each of Chrysler, Ford, and General Motors at any time between 1940 and 1977. Wood die and model makers are occupationally exposed to respirable wood dust (OSHA standard - 15 mg/m^3 for nuisance dust, American Conference of Governmental Industrial Hygienists Threshold Limit Value - 5 mg/m^3 for non-allergenic wood dust), plastic dust, solvents, and epoxy resin glue systems. Other substances to which workers are exposed also have OSHA standards (For example, formaldehyde, with a standard of 3 ppm; phenol, 5 ppm; and styrene, 100 ppm.)

The industrial hygiene characterization of the model shops, begun in Fiscal Year 1980, was completed in Fiscal Year 1982. An exposure file was also assembled to relate specific exposures to departments and operations. Further follow-up procedures, selection of controls, coding of detailed work histories, and analyses (cohort mortality and case-control) are under way.

J. Azo Dyes - A laboratory study was completed jointly with other agencies of the National Toxicology Program on the absorption, metabolism, and tissue distribution of ^{14}C-labeled Direct Blue 15 and Direct Red 2, both of which are benzidine-congener-based azo dyes. (These dyes were chosen on the basis of their high usage, availability, and purity.) Data on the metabolism of Direct Blue 15 indicated that most of the ^{14}C metabolites in urine extracts were identifiable as known metabolites, whereas only a small percentage of the ^{14}C in the urine fractions from the Direct Red 2 responded to gas chromatography assay for specific metabolites. Both dyes were found to accumulate significantly in the liver, a target organ in laboratory animals dosed with benzidine and the site of tumors in animals dosed with benzidine-based azo dyes. The study came about because of concern from a National Cancer Institute report that benzidine-based dyes cause cancer in rats. The Institute's study showed that benzidine, a component part of the dye and a known human carcinogen, was present in the urine of the exposed rats. The dyes are broken down by the animal to a bladder carcinogen. These data resulted in a special Hazard review and a health hazard alert warning that these benzidine dyes should be treated as carcinogens in the workplace. The workers exposed to these dyes include those involved in their manufacture, in work with textiles and leather, and in arts and crafts.

V. Research in Other Leading Work-Related Diseases and Injuries

A. Fractures, Amputations, Eye Losses, and Traumatic Deaths

1. Self-Tripping Power Presses - a. Many power presses are activated with controls requiring both hands to operate, so that both the workers' hands are in a safe position when the ram descends to stamp the item being pressed. If both controls are depressed, the ram can continue its cycle. If either control is released, the brake mechanism that holds the ram at the top of its cycle is engaged. Occasionally press operators attempt to reposition the metal part after the ram has begun its descent. A situation described as after-reach hazard occurs at the point of no return in the ram's cycle, when the time it takes for the brakes to stop the descent of the ram is insufficient to prevent the ram from striking the piece in the die. A press operator who inserts a hand into the field of operation may risk trauma or amputation.

The OSHA regulations governing power presses are based on limited studies. NIOSH therefore conducted a pilot study to begin to develop recommendations on the safe distance away from the hazard for locating the two-handed controls. After-reach times were measured at two different vertical locations of the two-handed actuator controls. Results indicate a significant difference in hand-reach speed between the two different locations of the two-handed actuators and point to the need for locating two-handed controls further away from the critical point of operation.

b. OSHA standards for power presses now prohibit the use of electro-optical actuators (light-curtains) as the mechanism for both actuating and safeguarding mechanical power presses. NIOSH industrial engineer researchers were asked by OSHA to evaluate a variance granted to one company so that the use of these devices could be assessed. Industry has expressed great interest in this project because of the potential gains in productivity that could result if expanded use of self-tripping systems is permitted. NIOSH compared the stress to workers feeding presses using the traditional two-handed safeguard/actuators with the stress to workers operating presses equipped with light-curtains. This study demonstrated no significant differences in the two groups of workers on several measures of physiologic stress, including heart rate, blood pressure, and subjective responses to a questionnaire. The principal findings have been transmitted to the Assistant Secretary of Labor for OSHA.

2. Machine Safeguard Systems - Amputations can occur when industrial machines are equipped with presence-sensing devices insufficient for protecting the machine operator. There are two types of these devices: radiofrequency/capacitance and photo-optical. NIOSH conducted a comparison study to characterize the major factors to be considered in the selection and use of photo-optical and radiofrequency/capacitance type devices for protecting workers at industrial machines. The study revealed limitations in the radiofrequency/capacitance-type device that had not been recognized previously by safety professionals. Specifically, these devices may respond to inputs other than the workers' hands and are therefore not effective for operations involving hand dye-feeding. As a result of this project, voluntary

standards organizations are considering additional requirements for the design and use of machine tool safeguards.

3. Video Display Terminals - The use of video display terminals (VDT's) and the possible adverse effects on vision were examined in a cross-sectional medical study of 283 members of a union of newspaper workers. Ergonomic characteristics of the VDT screen (i.e., brightness, resolution, glare, and flicker), which affect the legibility of VDT characters, were the best explanation of work-associated headaches, changes in visual function, and pain and stiffness in the muscles of the arms. No significant association was observed between VDT use and objective ophthalmologic findings. In response to a request from this union for a health hazard evaluation, NIOSH investigators administered a questionnaire and examined the vision of these workers. The tests were designed to discover cataracts and to assess the workers' refraction in comparison with the acuity needed to perform the work. NIOSH recommended ways to correct the lighting sources around the VDT's. These and other Institute findings about the impact of VDT's in the workplace have been incorporated into an instructional package for a 2-day training program designed for VDT workers.

B. Cardiovascular Diseases

1. Carbon Monoxide - The effects of acute exposure to carbon monoxide (CO), a commonly encountered industrial asphyxiant, have been well documented. Although little is known about the chronic exposure in humans, it is generally believed that adverse cardiovascular effects may result if carboxyhemoglobin levels reach 5%; therefore, the OSHA standard for CO for an 8-hour day has been set at 50 ppm. NIOSH has recommended that the standard for an 8-hour day be reduced to 35 ppm.

In an attempt to gain additional insight about the relationship of chronic exposure to CO and cardiovascular disease, NIOSH conducted a study of motor vehicle inspectors with chronic exposures to CO of 15 ppm. A previous cross-sectional medical study showed that toll collectors at the Triborough Bridge and Tunnel Authority (TBTA) in New York City are occupationally exposed to CO at levels averaging 63 ppm and have an increased risk of bronchitis, among other diseases. Based on this analysis, these workers are predicted to have a life expectancy 5-10 years shorter because of their occupational exposures.

A retrospective cohort mortality study is being conducted on all persons employed by the TBTA between January 1952 and February 1981. Many of these workers have been employed by the TBTA for 10-15 years. The Institute's analysis can thus be based upon length, as well as amount, of exposure. Environmental personal and area sampling will be conducted to measure CO, as well as other potentially hazardous agents in automotive exhaust. Previous environmental data collected by TBTA also will be used in evaluating cumulative exposures. Follow-up to ascertain vital status has found 4,400 workers alive, 300 deceased (for whom death certificates are being obtained), and 1,300 with unknown vital status.

2. Nitroglycerin - In 1977 and 1979, studies associated exposure to

nitroglycerin with a significantly elevated risk of death due to cardiovascular disease 10 and 20 years after a worker's last exposure to nitroglycerin (NG). In 1980, there were reports that NG also may be associated with brain cancer in females. An estimated 8,000 workers are exposed to NG and another 150,000 probably have been exposed in the past 25 years. In October 1979, NIOSH began a study to investigate the effects of NG exposure on a well-defined industrial population, both current and former workers of a large munitions plant.

Records of the complete plant workforce of 27,000 workers since 1947 have been collected, abstracted, and entered into a computer system. Approximately 7,000 workers maximally exposed to NG have been identified from the computer data base by using work history characterizations and data reduction methods. Detailed demographic variables and work histories have been coded for these maximally exposed workers and vital status follow-up is in progress. This study of a well-defined and extensively exposed population should permit verification of earlier reports of cardiovascular disease and brain cancer.

C. Reproductive Problems

1. Reproductive Toxicology - NIOSH completed studies designed to test in animals the reproductive effects of three organic oxides to which a large group of workers is exposed. The compounds tested were ethylene oxide (EtO), which is used as a sterilant, in renal dialysis, and in chemical synthesis; propylene oxide (PO), which is used mainly in chemical synthesis; and n-butyl acetate (BA), which is used extensively as a solvent in paints. NIOSH researchers looked for teratologic responses in animals exposed to these substances at various levels. As the levels of exposure were increased, there were signs of maternal toxicity, but none of embryotoxic or teratogenic effects. At much higher levels, there was evidence of maternal toxicity, minor anomalies began to appear, and animals exposed before breeding had a significant reduction in the number of corpora lutea, implantation sites, and live fetuses. In both animal species examined (rats and monkeys), however, the specific anomalies varied, and because of this inconsistency the morphologic variations cannot be considered teratogenic responses. No teratologic effects could be demonstrated at levels that were not toxic to the female animal. These findings indicate that if the mother is protected from illness, her offspring should also be protected.

2. The Effect of PCB's on Reproductive Outcome - Animal studies have indicated that polychlorinated biphenyls (PCB's) are fetotoxic. Some evidence also exists for teratogenic effects of PCB's in animals. The effects of PCB's on pregnancy outcome in humans are unknown. Personnel records collected in 1975 for a mortality study of workers exposed to PCB's in a capacitor plant contain a code of pregnancy leave. A preliminary record search into the live-born infants of women in this cohort between 1958 and 1975 was initiated for evidence of neonatal deaths and infants with low birth weight. Records on 430 live-born infants are being matched with controls in the same county by age, parity, race, and year of birth. This expanded evaluation will allow examination of such potentially confounding factors as tobacco, alcohol and drug use, medical history, and occupational history. Information on other adverse reproductive outcomes, including miscarriages, stillbirths, and

congenital defects will also be collected.

3. Effects of Exposure to Carbon Disulfide - Carbon disulfide is used in the treatment of cellulose with salts of xanthic acid to produce viscose rayon, as a solvent of sulfur, or as a dilutant for sulfur chloride in vulcanizing rubber; as a solvent for rubber cement; as an insecticide; as a solvent of phosphorous, fats, oils, resins, and waxes; and in the manufacture of optical glass. The current OSHA standard for carbon disulfide is 20 ppm. The toxicity of carbon disulfide has been recognized for many years and generally is associated with central nervous system effects such as loss of memory, excessive irritability, vertigo, melancholia, and, in severe cases, dementia. More recent studies indicate an increase in mortality and morbidity from cardiovascular disease and sexual impairment in both women and men. Sexual dysfunction, loss of libido, impotence, and semen changes have been reported in exposed male workers, and menstrual changes and increased frequency of fetal loss and premature births in exposed female workers.

NIOSH is studying pregnancy outcomes (especially fetal loss) in wives of male workers. Personnel records containing occupational histories were collected on all exposed and unexposed workers in the plant under study. A textile company that manufactures viscose rayon and other fibers was chosen, since the number of exposures other than carbon disulfide was small. The wives of exposed and comparison workers have been interviewed, and the computerization and editing of relevant data have been completed and analyzed. A cross-sectional medical and industrial hygiene study of this population also has been conducted.

D. Neurotoxic Illness

1. Neurobehavioral Toxicology: Spray Paint Solvents - NIOSH examined the neurobehavioral response to methyl ethyl ketone (MEK) and toluene exposures in humans, as part of a series of laboratory investigations into the effects of spray paint solvents. Adult volunteers received single exposures to either MEK or toluene at the current OSHA Permissible Exposure Limit, and then were examined in a test paradigm that incorporated changes in the eyeblink reflex as the behavioral reference. For the purposes of this study, NIOSH researchers used an effect known as prestimulus inhibition (PI). The vigor of the eyeblink reflex is weakened in normal subjects when they hear a brief burst of low-intensity white noise (static) just before the reflex is induced (in this case, by a puff of air to the subject's face).

The subjects in this study were first tested for 2 hours for baseline values, then were monitored for 4 hours while they breathed the air in a chamber into which the solvents had been pumped. Thus they received half the exposure allowable in the workplace. Subjects who received toluene at a concentration of 100 ppm for 2 hours exhibited no change in their pattern of PI compared with their pre-exposure baseline scores. However, subjects who received 200 ppm of MEK for the same period showed a uniform loss in the inhibitory potential. This effect is consistent with other observations of generalized changes in behavior and the central nervous system after exposures to related ketone solvents, but it represents the first such finding for MEK. The results indicate that MEK has an acute, reversible, depressive effect.

These studies will continue and will enable NIOSH to ascertain short-term exposure limits for paint spray solvents.

2. Neurobehavioral Effects of Carbon Disulfide - The Institute has completed an industrywide study of the effects of carbon disulfide (CS_2). A comprehensive evaluation of 156 viscose rayon workers and 233 comparison workers was performed. The CS_2 workers had generally been exposed to the OSHA limit of 20 ppm CS_2 or below. Not only did the exposed workers have poorer scores on behavioral tests of short-term memory and manual dexterity, this group also had significantly more complaints of symptoms associated with central nervous system effects, for example, difficulties in sleeping, dizziness, fatigue, and memory lapses. Findings from the neurobehavioral component showed workers to have statistically significant reductions in the conduction velocity of peripheral nerves. The significance of these findings is the identification of a low-level toxicity of carbon disulfide at levels previously uninvestigated. The results indicate a need to limit workers' exposure to levels as low as feasible.

E. Noise-Induced Hearing Loss

1. Occupational Impulse Noise - NIOSH conducted a study to characterize sources of impact noise found in a variety of industries. A problem in this area of research has been that all noise has been measured according to standards involving parameters that did not include impulse noise. A first step for NIOSH researchers has therefore been to develop techniques for measuring this type of noise. Sophisticated wide-band engineering methods for capturing and recording impulse noise were used at 12 different plant sites in industries such as foundries, forges, steel pipe and sheet metal fabrication plants, and bottlers and barrelers. These data are being analyzed in an effort to characterize both the differences and similarities between different noise sources, and have already allowed NIOSH to develop specifications for dosimeter responses. Employee exposure and hearing histories must be compared with those of workers exposed to the same level of continuous noise. These engineering techniques will allow NIOSH to determine the amount of workers' hearing loss associated with impulse noise exposure and to study the effectiveness of hearing protectors against intermittent noise.

2. Personal Hearing Protection Devices - In order to determine how effective hearing protectors are in everyday use, a field investigation of insert-type hearing protectors (earplugs) was conducted. Tests of 420 workers at 15 industrial plants indicated that 50% of the workers received less than half the potential protection demonstrated in laboratory testing. The field investigations included evaluations of five general types of earplug design: twin-flanged; single-flanged; acoustic wool; custom-molded; and expandable acoustic foam.

Earplug distributors label their products with noise-reduction indexes based on data from standard audiometric laboratory tests. Although earplugs can provide adequate protection from noise hazards, workers generally wear them incorrectly; thus, distributors' estimates may greatly exceed the actual protection of the earplugs. The large differences between the laboratory-derived attenuation values provided by distributors and actual attenuation in

industrial settings should be considered by employers when choosing earplugs for their employees. Workers can be endangered from excessive noise exposure if employers assume that workers will be protected to the extent indicated by laboratory tests.

F. Psychological Disorders

1. Machine-Paced Work and Stress - The U.S. Postal Service has greatly expanded its use of machines to sort mail, as these machines can perform much more rapidly than can human workers. Each sorting machine is served by a crew of 16 workers who perform different tasks, such as keying and loading. NIOSH concluded a questionnaire survey of job stress and health complaints among Postal Service employees performing machine-paced sorting operations, compared with other postal employees performing self-paced work. The survey covered 50 postal locations in the United States and included 6,700 respondents (3,417 machine-paced operators and 3,313 self-paced workers).

The results indicated that machine-paced workers reported higher levels of job stress than did self-paced workers. In particular, they reported higher workload, greater work pressure, higher memory and concentration demands, greater dissatisfaction with their opportunities to utilize their skills, and less supervisor support. Machine-paced workers also reported higher levels of health complaints related to visual, muscular, gastrointestinal, and psychological disorders. The Institute's suggestions for remedial actions included redesigning the workstation to allow employees greater control over the work process and to reduce the biomechanical loads imposed by the job tasks, changing the schedule of work task rotation, and promoting positive supervisor and employee interactions.

2. Stress Reduction - During Fiscal Year 1982 a stress management training program was established and evaluated in a blue-collar work group. In small groups at the worksite, 42 highway maintenance workers received training in biofeedback and muscle relaxation. Post-training results indicated a significant lowering of muscle tension levels in the trained groups compared with controls, an outcome that replicates earlier results for nurses and retail sales clerks. Muscle tension levels measured at a 3-month follow-up were well below baseline levels in the trained groups, although some regression from post-training levels was evident. Significant improvements in self-reported indices of sleep behavior, health complaints, anxiety, and alcohol use were found, many in both trained and control groups. These results indicate that stress management training at the worksite may be successful in reducing stress for workers in jobs for which work conditions cannot be redesigned.

VI. Surveillance

An essential component of the Institute's efforts to prevent illness and control hazards in the workplace is the surveillance program, which is designed to identify occupational safety and health problems by detecting and defining epidemiologically significant changes and trends. Several key aspects of the NIOSH surveillance program, which continuously assesses the magnitude and extent of job-related illness, exposures, and hazardous agents, are described below.

A. National Occupational Exposure Survey - Large-scale periodic probability samples of potential exposures in American workplaces, the National Occupational Hazard Survey (NOHS) and the National Occupational Exposure Survey (NOES) constitute the centerpiece of the Institute's hazard surveillance research program. All its hazard surveillance projects are linked to this main survey effort. The ingredients of trade-name products, for example, must be clarified in order to gain information on the products noted as potential exposure agents. NOHS, the first survey, began in 1972 and provided a foundation of experience in sampling statistics, data editing and analysis, resolution of trade name products into ingredients, and managing the field survey team. This experience is being applied in the Institute's second nationwide data-gathering endeavor, the NOES. The acquisition of the Dun and Bradstreet file of U.S. industries permitted the development of a probability sample of facilities for use in NOES. This list of facilities also provided the demographic information required for mapping NOHS data at the county, State, and Standard Economic Area level for the entire Nation. A Material Locator System makes use of trade-name product ingredient information for alerting worker groups to the nature of chemical hazards in their working environment.

For NOES, a sampling strategy has been implemented, and facilities have been selected for inclusion in the survey. Surveyors have been recruited, trained in observational survey techniques, and deployed to the survey sites. Data-editing software has been developed. By the end of Fiscal Year 1982, 3,216 facilities employing 1,150,000 workers had been surveyed.

The NOHS data base continues to provide important information to a wide spectrum of data users. It functions as a locator file for occupational health professionals interested in identifying occupation groups at risk due to potential exposure to health hazards. It also can be used to produce National estimates of numbers of workers potentially exposed to any of the more than 9,000 chemical and physical agents observed in this survey. During Fiscal Year 1982 more than 200 requests for information from NOHS resulted in over 5,000 reports.

B. National Electronic Injury Surveillance System (NEISS) - This system of work-related injury reports from a sample of 66 representative hospital emergency rooms is being carried out through an interagency agreement with the Consumer Product Safety Commission. The NEISS system has for the first time permitted the calculation of age- and sex-specific injury incidence rates, by month, for the United States. During the first 9 months of 1982, an estimated 2.4 million patients with occupational injuries were treated in emergency

rooms in the continental United States. Of these, 1.83 million (76%) were males and over 563,000 (24%) were females. The rates of injuries treated in emergency rooms, based on Bureau of Labor Statistics' estimates of hours worked, show marked differences among groups and times. All age groups showed seasonal variations, which were most pronounced for males aged 16-17 years and 20-24 years. The incidence appears highest in summer and lowest in winter for workers aged 20 years and older. The trends are similar but less obvious for younger age groups. On the basis of these estimates, male workers aged 18-19 years appear at highest risk of job-related injury requiring treatment. During the summer months, a male worker in this group is 5 times more likely to be injured than a male worker aged 55 years or over. Differences in job tasks and exposures specific to male and female workers most likely account for the observed differences in risk. The inexperience of younger workers may be a major factor in the higher incidence of injuries in this group. One hypothesis for the marked seasonal variation for males is that industries with characteristically higher risks of injury, such as construction, often employ their largest numbers of workers, including new workers, during the summer.

C. Case-Comparison Study of Maternal Employment and Fetal Outcome - By utilizing vital statistics record sources, NIOSH has examined the relationship between maternal employment characteristics and fetal outcomes. This effort is being evaluated for potential extension to other vital registration areas and for potential detection of trends and determinants of work-related reproductive failure.

Data for live births, fetal deaths, and congenital malformations in New York City for 1979 were examined to assess the relationship between maternal employment and fetal outcome. The study represents a near-complete data base for fetal deaths and malformations in New York City for 1979. The figures compiled, which may be considered representative of urban populations, include 1,846 fetal deaths and malformations in 815 live-born infants. Statistical analyses were performed by matching with 11,022 normal infants.

Mantel-Haenszel analyses were used to estimate odds ratios for 15 industry groups and 18 occupation groups. Elevated risk of fetal death or malformation in a live-born infant were identified in the following occupations: service occupations; handlers and equipment cleaners; administrative support occupations; and machine operators. Industries with elevated risk included finance, transportation, personal services, retail trade, and entertainment. Future analyses will consider the occupational history of both parents and will focus on high-risk occupations within industries, gestational age at fetal death, cause of death, and type of malformation.

D. Parental Employment and Spontaneous Abortion - The principal objective of this study is to examine the relationship between spontaneous abortions and the employment characteristics of parents of the aborted fetus. Two separate avenues of study are being pursued: 1) the identification of occupation and common exposures associated with adverse reproductive outcomes; and 2) the examination of parental employment characteristics and non-occupational exposures with reference to spontaneous abortion and the karyotypes of the aborted fetus.

The study is based on a consecutive series of women seeking care for spontaneous abortion at three New York City hospitals. Of the 5,770 women identified for study, 4,454 were interviewed. In 2,342 of those interviewed, the products of conception were retrieved for tissue culture and in 1,382 instances, a karyotype was obtained. Controls were drawn from women delivering at 28 weeks of gestation or later. Two associations between employment and karyotype appeared to persist after confounding factors were controlled. These are 1) maternal employment in a cleaning service occupation, with chromosomally normal abortions; and 2) parental employment in a hospital or nursing facility with monosony X. Overall, the results show that parental employment did not appear to influence the type of spontaneous abortion.

E. Blue-Collar Workers - Most epidemiologic research studies are limited by a lack of regional non-exposed control subjects. Further, no National controls are available to NIOSH with data collected by consistent equipment and procedures. NIOSH has conducted a study of over 2,300 employed subjects, nearly 1,400 of whom can be classified as blue-collar workers not exposed to disease-causing agents. Industries in the State of North Carolina composed the pilot study, because of the combination of race, sex, and age characteristics in the workforce. Subjects from other localities are being added to the overall pool.

As a result of this study, NIOSH epidemiologists have been able to develop prevalence rates for symptoms of lung disease and X-ray abnormalities and to formulate models showing the relationship of pulmonary function indices with age, height, and weight for different race, sex, and smoking groups. For example, because blacks tend to have smaller lung volumes than whites, past crude statistical practice has been to multiply the predicted values of whites for lung function tests by a factor of 0.9 to derive an estimated value for blacks. Information from this NIOSH control group has allowed refined formulas to be devised to replace this estimation.

F. Cooperative Projects - NIOSH is responsible for estimating the prevalence and incidence of occupational lung disease and determining safe exposure levels in the workplace. To accomplish this requires medical surveillance of the workers and environmental surveillance of the workplace. Given the size of the workplace nationwide, it is not possible for the Institute alone to completely fulfill this responsibility. Often the worker's employer has a program to provide periodic medical examinations for the employee and may also have an industrial hygiene program. Although these data are intended for clinical evaluation of each worker, they may be adequate for epidemiologic studies. A company may have neither the interest nor expertise to perform such studies; however, the company clearly has the best position from which to collect these data for both medical and epidemiologic purposes. Company employees are present every day, they control the schedule and production, and they have a legal and moral obligation to keep exposure levels within safe limits. It thus can be of advantage to all parties to study the company environmental and medical data cooperatively. At the same time, NIOSH can help the company improve its surveillance program.

The Institute has two cooperative projects that utilize the medical and

environmental data collected by private companies. Attapulgite clay is mined and milled by two companies that have an ongoing medical surveillance program. NIOSH has conducted several industrial hygiene surveys and has acquired medical information from the firms for analysis. While the data were not collected specifically for epidemiologic purposes, they will provide a satisfactory analysis of this industry.

Vermiculite is mined and milled in several areas, but the most predominant deposit is found in Libby, Montana. A company in Libby has cooperated with NIOSH in a study of the morbidity and mortality of their workers exposed to a tremolite-contaminated ore. Data from the workers' annual medical examinations will allow NIOSH to assess the effects of tremolite and dust exposure on lung function, respiratory status, and mortality. The data provide a picture of changes in health status over 10-20 years. Together with an enormous number of company environmental samples taken since 1973, this information provides an opportunity to prospectively and cross-sectionally evaluate the health effects of tremolite and dust exposure on workers and, in addition, establishes a data base for future surveillance. The results of this study will also be utilized by the Department of Labor to revaluate the asbestos standard for tremolite.

G. Accident Investigation Program - NIOSH has initiated a program utilizing epidemiologic methods to investigate fatal occupational injuries. Job fatalities usually are investigated only for determining compliance with regulations, and no systematic data base exists that provides basic descriptive epidemiology of the causes and circumstances surrounding these incidents. The Institute's pilot program has begun to provide a data base that will also include comparative information on noninjured coworkers. The basic research design is that of a case-comparison study that will provide estimates of relative risk under various conditions of exposure. Several investigations have been carried out; examples include investigations of a crane-related fatality in a subway tunnel in Boston, of the death of a worker who fell 15 feet from a scaffolding to a concrete slab, and of a crane-related electrocution at the construction site of a large water storage tank in Pennsylvania. The information gathered in these investigations has been useful to company officials, as well as to State medical officers, and may prove helpful in future prevention efforts.

H. Registry-Based Occupational Cancer Surveillance - Phase I - This study, which supported a population-based case-control study of respiratory cancer and employment, was carried out in two northern California counties. The resources of the California Department of Health Services were employed to conduct the study through the California Tumor Registry. Preliminary findings of the analysis, which controls for smoking, support the association between respiratory cancer and asbestos, with measured risk being manifest with increased years of employment. No statistically significant increased risks for other blue-collar occupations - shipyard, petrochemical, metal, constructon - was seen. Further analyses will be undertaken by NIOSH in an attempt to reconcile these observations.

VII. Control

NIOSH discovers, assesses, and improves measures to control work-related injuries and illnesses through the disciplines of engineering, ergonomics, and industrial hygiene and safety. NIOSH recommends engineering systems, including process design, protective equipment, and work practices, so that occupatonal hazards can be reduced. In addition, NIOSH develops methods of environmental and medical monitoring to detect failures in these control systems.

A. Comprehensive Safety Recommendations

1. Precast Concrete Products - Precast workers suffer a high rate of traumatic injuries, musculoskeletal injuries such as sprains and strains, dermatologic problems (related to handling moist concrete and form-release agents), and noise-induced hearing loss, caused by machinery noise.

According to statistical analysis of injury data from 1976 to 1980, this industry is one of the most hazardous of the manufacturing industries. The data also suggest, however, that these injuries can be prevented through better compliance with existing standards rather than pointing to the necessity for new or modified standards. NIOSH and the National Precast Concrete Association, the American Concrete Pipe Association, and the Prestressed Concrete Institute are working together to develop practical safety guidelines for use in the industry. These recommended safe work practices should directly benefit production workers, since they cover the tasks, tools, and equipment that have been identified through analysis of injury data as most hazardous.

2. Oil and Gas Well Drilling - Although the estimated population of workers at risk in this industry is less than 80,000, data indicate that approximately 40% of U.S. land-based drilling rig workers sustain recordable occupational injuries each year, with compensation losses averaging up to 8.5% of the total industry payroll. During Fiscal Year 1982 NIOSH analyzed injury data and accident case histories that identified the most frequent and serious sources of injury in the industry. The analysis revealed that tasks and tools specific to the industry, for which there are no specific Federal safety standards, are among the most hazardous to workers. For example, the handling of drill pipes, collars, and casings was responsible for more injuries than any other task (22% of the accidents studied.) Tongs, the large, counterweight, suspended wrenches used on drilling rigs to "break out" the torqued couplings on the drill pipe, accounted for 15.3% of the accidents studied.

3. Fabricated Structural Metal Industry - Like the two preceding studies, this project represents extensive analysis of injury data and accident case histories to focus attention on hazards facing workers in the fabricated structural metal industry. Materials-handling tasks were identified as the prevalent activities resulting in worker injury. Lack of adequate personal protective equipment, especially eye protection, during such tasks as welding, burning, grinding, and chipping contributed to over 20% of the injuries studied. Use of metalworking machinery was the most prevalent

industry-specific factor contributing to worker injury, accounting for 7.4% of the accidents analyzed in the study. Inadequate machine guarding, lack of safety devices such as proximity detectors and dual-activator controls, and improper worker procedures (e.g., improper die and punch alignment on punches) caused worker injury during operation of metalworking machinery. Recommendations for safe work practices were developed based on the identified hazards.

B. Respirators

1. Testing and Certification of Respirators - The Institute has issued 261 approvals, extensions, and denials of certification for respirators and personal sampler units for coal mine dust. In related efforts, several research projects are under way to determine 1) better ways to evaluate respirator sorbent efficiency and aerosol filter efficiency under a much greater variety of conditions than present methods allow, 2) the effects of filter resistance and efficiency on protection factors, 3) optimum flow rates for aerosol filter testing, and 4) the physiologic response to wearing respirators with protective clothing.

The Institute tests and certifies two basic types of respirators: air-purifying, which includes dust, fume, and mist respirators, chemical cartridge respirators, and gas masks; and atmosphere-supplied, which includes self-contained breathing apparatus and supplied-air respirators. Both types of respirators are submitted for approval under Title 30, Part 11 of the Code of Federal Regulations. The quality control documentation is reviewed for these respirators. Respirators purchased from the open market are tested as part of an audit-test program, which also performs audit testing in response to field complaints and provides technical support for standards development.

By approving safe and reliable respirators, the Institute contributes to protecting the worker against hazardous atmospheres and environments that are immediately dangerous to life and health, such as those occasionally found in industry, mining, and fire fighting. Respirators provide an alternate means to employers and employees of reducing exposure to the airborne contaminants that cause lung disease. Certifying respirators directly benefits employees by ensuring that the respirators they use to reduce their exposure to contaminants meet certain minimum requirements for performance and construction.

2. Respirator Research - Ergonomics - Not only does the Institute seek to ensure that respirators protect the workers who use them to the greatest extent possible, it also studies ways to encourage the proper use of respirators. In two such studies, NIOSH examined the use of respirators in hot environments and by workers who have lung disease.

In the first study, researchers looked at the effects of wearing respirators while working in hot environments. Under full-, half-mask, or no mask conditions, five healthy subjects exercised at low or moderate treadmill levels while exposed to 25°C or 43.3° C ambient heat in individual one-hour sessions. These subjects experienced increases of 5% in heart rate, 24% in minute ventilation, 5% in oxygen consumption and 0.6°F in oral temperature

when tested with a full-face mask over the same conditions with no mask. The half-mask tests gave intermediate readings on these measures. The subjects' responses to a questionnaire about comfort did not correlate well with these physiologic changes. These results indicate that wearing a full-face respirator causes an increase in physiologic strain, which reduces capacity for physical performance and tolerance of heat. Recommendations for reducing this strain from wearing respirators included reducing dead air space, covering less of the surface of the face, and minimizing the time a worker must use a respirator.

The Institute also examined the potential effects on subjects with lung disease of the added resistance to breathing caused by respirators. During this study, 49 men performed submaximal exercise with and without the added resistance of wearing a respirator. Twenty of these subjects had normal lung function, 19 had mild obstructive lung disease, and 10 had moderate airways obstruction. Researchers measured several indicators of ventilatory efficiency, including oxygen uptake, heart rate, breathing rate, minute ventilation, partial pressure of carbon dioxide, and mouth pressure. The results for the three groups were similar on all these tests. The responses to a questionnaire about comfort were similar as well. This work should greatly aid physicians in determining who can safely wear respirators and reassure many American workers who now are not wearing respirators because of unfounded fears about acute physiologic stress.

3. <u>In-respirator Mask Monitor</u> - Formaldehyde, which NIOSH recommends should be handled as a potential occupational carcinogen, is a colorless gas, but its pungent, suffocating odor allows personal protective equipment, i.e. respirators, to be used as an exposure control. The use of respirators is currently limited by OSHA to situations involving exposures to contaminants that possess odor or irritation properties adequate to warn the user of malfunction or leakage. Unfortunately the perceptual threshold for these warning stimuli often does not coincide with the OSHA exposure limits. If the perceptual threshold is close to the safe limit, a worker may unknowingly receive a significant dose. Conversely, if the odor threshold is far below the regulatory limit, the user may doubt the performance of a properly functioning respirator or become desensitized and fail to note a hazardous increase in concentration. To address these problems, a device has been developed that measures the concentration of hazardous vapor within the respirator mask and sounds an alarm in the event of a significant accumulated exposure. The device is an electro-optic monitor combining chemochromic transparent film technology and the automated electro-optic sensing of film color. Although developed for formaldehyde, the technology is applicable to many toxic gases. This in-mask monitor will directly benefit the worker by giving a direct readout of accumulated exposure and by sounding an alarm when the exposure is significant, thereby warning both of the end of the service life of the respirator and of leakage.

4. <u>Field Evaluation of Powered Air-Purifying Respirators</u> - Three field studies were conducted in Fiscal Year 1982 to evaluate the degree of protection afforded by tight-fitting facepieces and helmeted powered air-purifying respirators and to evaluate the appropriateness of 1,000 as the assigned protection factor. A protection factor represents the ratio of the

concentration of airborne contaminant outside a respirator facepiece to the concentration of the contaminant inside the facepiece. The assigned protection factor of 1,000 was initially arrived at through laboratory testing under conditions that now appear not to approximate conditions in the workplace. Statistical analysis of the distribution of workplace protection factors derived from these field studies, which were conducted under conditions found in the workplace, revealed that the protection factor of 1000 may be inappropriately high. A Respirator Information Notice was issued to alert the occupational safety and health community of the results of this research.

5. Lead Aerosol Penetration Study - NIOSH conducted a study, at OSHA's request, to evaluate the real-time efficiency of dust, mist, and fume and dust/mist filters when challenged by lead aerosol under various laboratory conditions. The efficiency of these filters was evaluated as a function of concentrations of the challenge aerosol and preconditioning with 85% relative humidity for 8 hours. Test results indicate that the efficiency of the filters was not affected by test variables. In general, it appears that the very high initial efficiency of electrostatic felt filters decreases with increased mass loading. The extent to which the efficiency decreases appears to be different for each filter manufacturer.

The pure mechanical-type filters, in general, had lower initial efficiencies than the electrostatic felts, but the efficiency of these filters improved with increased mass loading. The observation with electrostatic felts that efficiency decreases within the limits of mass loading is significant because the total occupational dust concentration, not necessarily the contaminant concentration, will determine the rate of efficiency decay of these filters.

C. Particulate Control: Research-Snagging Grinders - The objective of this research is to improve control of the respirable dust generated by large snagging grinders, based on a better understanding of the process in which the dust is formed and transported into the worker's environment. Snagging grinders, which are used in foundries to clean castings, typically have 30-inch diameter wheels that turn with a surface speed of about 140 mph. The health hazard that motivated the Institute's research arises when materials are ground that contain a toxic component, such as brass, which contains lead, or ferrous sand castings, which contain silica. When brass or ferrous castings are ground, the concentration of these toxic substances in the cleaning area frequently exceeds the maximum limit permitted by OSHA, leading potentially to lead poisoning or silicosis. This theoretical and experimental work has revealed that respirable particles generated by the grinding process enter the working environment by adhering to the wheel as well as being carried by the airflow around the wheel. This understanding has guided the development of effective control measures involving both a baffle and an exhaust, so that particles scraped from the wheel are immediately exhausted. Applying these measures should help to prevent occupational lung diseases and lead to a healthier working environment for snagging grinder operators.

D. Push-Pull Ventilation Techniques - Local exhaust ventilation is an effective technique for removing fumes from the workplace, if the exhaust can

be placed close to the emission source. However, if the emission source is over 2 feet from the exhaust, a great quantity of room air must be exhausted, and control is ineffective if not impossible. The physical configurations of many industrial processes create such a situation.

To control emissions over these greater distances while exhausting less room air, the emissions can be pushed with a jet of air toward the exhaust. This is commonly referred to as push-pull ventilation. During Fiscal Year 1982 NIOSH investigated the use of push-pull ventilation on open surface tanks, such as those used for chrome plating. The results of this research showed that emissions could be controlled on tanks up to 6 feet wide, while using less than 25% of the exhaust necessary if only pull was used. Thus, push-pull ventilation enables control of emissions in difficult situations and at the same time reduces energy costs.

This effort, although it involves use of a simulated plating tank, will provide control information for a wide range of industrial processes. Thus, it addresses the NIOSH goal of preventing occupational lung disorders associated with operations like chrome plating (associated with lung cancer) and cleaning, degreasing, and pickling (associated with respiratory irritation and pulmonary edema).

E. Analytical Methods

1. - Inorganic Methods Development The Institute has developed methods of sampling and analysis for the following inorganic materials: vanadium pentoxide and copper fume. These workplace hazards exemplify the increasing focus on very specific compounds; methods that "speciate" particular compounds are needed to replace the methods that simply quantify any and all compounds that contain a particular element. The method for vanadium pentoxide, for example, quantitates that compound separately from other vanadium compounds. The Mine Safety and Health Administration requested the vanadium pentoxide sampling and analysis method; it enables worker exposure to this compound to be monitored distinctly from that of related compounds having different health effects.

2. - Study of New Laboratory Techniques Both the complexity of the atmosphere of the workplace and the questions asked about the workplace are increasing. This situation requires a corresponding sophistication of the analytical capabilities of the Institute. Two major instruments with data analysis systems were recently acquired and are now providing useful information in elucidating the composition of a variety of workplace atmospheres.

a. Application of GC/MS/DS Techniques to Industrial Hygiene Analyses--Whenever occupational illness is due to chemical exposure, knowledge of the identity of the agents responsible for the toxicity may be required before measures can be taken to protect workers. Subsequent measurements may be needed to demonstrate the effectiveness of controls and compliance with recommendations. Computerized gas chromatography/mass spectrometry (GC/MS/DS) is an increasingly powerful tool for such identifications and measurements.

NIOSH has applied recent advances in GC/MS/DS instrumentation to the support of its research projects and field studies. Examples from Fiscal Year 1982 are use of chemical ionization and accurate mass determinations to determine empirical formulas and to postulate structures for the major components of a bulk sample of glycidyl ethers. Some belonged to a class of compounds that could not be revealed by the application of previous standard techniques.

b) A method using high-resolution selected ion monitoring was developed for the quantitation of several common nitrosamines. This technique provides a high sensitivity and specificity not otherwise available.

c) By using the same technique, a method was developed for the quantitation of nitropyrene in diesel exhaust particulate. Nitrated polycyclic aromatic hydrocarbons, the glycidyl ethers, and especially, the nitrosamines are typical of compounds found in the workplace that are of current concern because of their high toxicity and possible carcinogenicity.

3. Portable Gas Analyzers - One of the most perplexing situations still facing the occupational health specialist is the problem of obtaining immediate qualitative and quantitative information about hazardous substances in complex gas mixtures. This type of data may be necessary on an immediate basis, particularly at accident sites, and is extremely useful for screening during survey work. Organic gases and vapors represent potential occupational hazards to many industrial workers in a wide range of occupations. Twelve million workers are exposed to ketones, 2.5 million to hexane, and 0.5 million to benzene, to cite three hazardous compounds amenable to direct gas chromatographic analysis in the field.

To analyze these hazardous organic gases and vapors and to address some difficult sampling and field-analysis problems, a portable gas chromatographic air analyzer was conceived in a 1976 NIOSH/EPA-funded feasibility study and developed through a series of NIOSH/EPA-sponsored contracts. The analyzer is now a commercial reality. This microprocessor-controlled instrument is based upon silicon etching and micro-electronics technologies. The unit is smaller than a typewriter, weighs 9.2 Kg, and can house up to seven separate and complete gas chromatographs. Each gas chromatographic unit uses a different capillary or micropak column, which allows a wide variety of toxic gases to be separated. A single calibration is required for concentrations ranging from 1 to 10^6 ppm of 100 different gases.

The portable gas chromatograph can measure many compounds which can cause occupational cancers and reproductive and dermatologic problems. In addition, the instrument can assist workers directly by giving an immediate characterization of their workplace environment and by sounding an alarm if any of 10 user-chosen contaminants exceeds a preset level.

4. Dust-Measuring Instruments - The Aerodynamic Particle Sizer (APS) was developed under partial funding by NIOSH to measure aerosol particles in the size range of 0.5 - 15 micrometers. This size range is of special interest to NIOSH because of its relevance to respiratory disease. Aerosol particles in this size range can reach the alveolar gas-exchange regions in

the lung, where the particle-removal mechanisms are least efficient, and can cause pneumoconiosis and other diseases.

The APS, which is now commercially available, won an Industrial Research IR-100 award as one of the 100 most technically significant products of 1982. The APS allows easy and rapid high-resolution measurement of the size distribution of particles. It measures a particle's aerodynamic size, which is related to its behavior in the lung. Previously, aerodynamic size could only be measured inconveniently, slowly, and with poor resolution.

Two new instruments for measuring personal exposure to respirable dust have been developed under joint funding by NIOSH and the Bureau of Mines. These instruments, which detect dust by different mechanisms, are intended for use in mines and other industrial locations to allow rapid assessment of exposure to respirable dust.

One instrument measures dust mass by using a tapered-element, oscillating microbalance. This device replaces the filter cassette generally used as part of a personal dust sampling system. At the end of a sampling period, the instrument is attached to a readout unit for assessment of the time-weighted average exposure, which obviates the need for collecting a filter and reading it in the laboratory. The other instrument is the miniRAM (real-time aerosol monitor), a miniaturized, passive, light-scattering dust monitor. This instrument is small enough to be worn on a shoulder strap or from a belt and provides a direct readout of dust concentration, as well as a cumulative time-weighted concentration.

VIII. Health Hazard Evaluations

The purpose of this program is to respond to requests for assistance from employers, employees, employee representatives, other Federal agencies, and State and local agencies. These requests result in (a) an evaluation of whether chemical, biologic, or physical agents are hazardous as used or found in the workplace, and (b) recommendations for control procedures, improved work practices, and medical screening to reduce exposure levels and subsequent health effects. This program is conducted pursuant to Section 20(a)(6) of the Occupational Safety and Health Act. Approximately 15 person-years of industrial hygiene support were provided to the program from NIOSH's 10 Regional Offices.

During Fiscal Year 1982 NIOSH received 400 general industry requests for health hazard evaluations and technical assistances (HETA's) pursuant to the Occupational Safety and Health Act. This represents a 16% decrease from Fiscal Year 1981, when 478 requests were received. Most of the decrease was in requests from employees and unions (63 fewer than in Fiscal Year 1981).

Four hundred fifty-seven (457) site visits were conducted (including those conducted through medical service contracts and cooperative agreements), and 464 HETA's were completed during the year. The total for the year included 248 final reports (All final reports are available through the National Technical Information Service.), 88 letter reports (most after a site visit), and 128 other close-outs, which include referrals to other agencies.

The health hazard evaluation cooperative agreements with the Harvard School of Public Health, the University of North Carolina School of Public Health, the University of Utah, and the New Jersey State Health Department also were more productive; these organizations completed 20 projects. As part of the attempt to increase productivity and work more closely with State health departments, in July 1982, two third-year Epidemic Intelligence Service (EIS) Officers were assigned to work in State health departments: one in Washington and the other in Virginia. Also, interested State-based EIS Officers have now been formally made available to participate in HETA's. Through the NIOSH survey of State health departments conducted in Fiscal Year 1982, we can now identify State health department personnel interested in participating in HETA's.

There were several important findings in HETA's completed in Fiscal Year 1982:

Pulmonary - A high prevalence of talcosis was found at a rubber manufacturing plant in Rhode Island and a high prevalence of silicosis was found at a foundry in Wisconsin, countering the impression that these diseases have become rare.

A detailed medical study of meat wrappers' asthma was completed at a Colorado facility, and a high prevalence of metal fume fever was found in welders at a nickel-copper alloy fabrication plant in Wisconsin.

Fire Fighters - Several studies of fire fighters were completed in Fiscal Year

1982. Two demonstrated a high prevalence of respiratory symptoms in fire fighters after fighting large fires at a hotel and a chemical warehouse. An evaluation of the long-term consequences of these exposures is under way in New Jersey. The risks of chemical exposures for fire fighters also were evaluated at several fires involving hazardous chemicals (chemical storage facilities and PCB's from transformers). Another study demonstrated a significant risk of hearing loss in fire fighters.

Office Environments - Over 50 health hazard evaluations involving office workers were completed. Although most problems were probably due to inadequate ventilation, some studies demonstrated problems due to contaminated air from vehicle exhaust or other sources of contamination entering the office ventilation system. A study at an office building in Idaho found a significant hazard for that building and the surrounding community due to a large gasoline leak from a nearby storage facility. An evaluation of exposures to trinitrofluorenone (a mutagen) from copier/printers demonstrated no significant risk of exposure during routine operation of these machines.

Formaldehyde - Formaldehyde exposure was the subject of several evaluations. A study at several public housing units in New York demonstrated persistent levels of formaldehyde in the homes, despite the removal of urea formaldehyde insulation a year earlier. Significant formaldehyde exposures also were demonstrated for renal dialysis workers and for medical students in anatomic dissection laboratories.

Construction Industry - Significant exposure risks for construction and maintenance employees were discovered in several health hazard evaluations. Roofing workers were studied to evaluate exposures to solvents during the installation of vinyl roofing systems and polynuclear aromatic exposures during roofing tear-off operations. Significant risks for exposure to solvents and other chemicals among municipal sewer workers were found in a study in Ohio.

NIOSH also conducts a Mining Health Hazard Evaluation Program, which completed 51 health hazard evaluations (32 mining and 19 general industry) in Fiscal Year 1982. Forty-nine new requests were received (23 mining and 26 general industry). Of these new requests, 22% involved building-related problems, 45% involved various chemical hazards; 31% involved mineral hazards, such as silica and asbestos; and the remaining 2% dealt with physical hazards. Several mining HHE's yielded noteworthy findings. 1) Respirable silica exposure was found to be significant in two lignite surface mines investigated, as 35%-40% of the environmental samples exceeded the NIOSH-recommended standard. 2) Eleven percent of current workers and 19% of participating workers were found to have pneumoconiosis in a kaolin mill investigated, where the dust exposure was uncomplicated by silica or asbestiform fibers. 3) Silicosis was identified in 11% of current workers and 20% of former workers in a group of mica/feldspar mills investigated. The NIOSH-recommended standard for exposure to respirable free silica was exceeded in 53% of the environmental measurements.

IX. Training and Workforce Development

A. Educational Resource Centers - NIOSH continued its support of the Educational Resource Center (ERC) Grant Program. Spread throughout the United States to serve each region of the country, the 14 Centers include several multi-institution complexes involving 30 different universities. The major objectives of the ERC program are to increase the supply of professional occupational health physicians, nurses, industrial hygienists, safety engineers, toxicologists, and epidemiologists; to provide multidisciplinary academic degree programs; to provide competency-based continuing education courses for occupational safety and health practitioners; and to serve as regional resource centers that provide technical assistance to outside institutions.

ERC enrollment increased dramatically in earlier years and has maintained a stable level in recent years, as indicated below.

ERC Enrollment

	FY'78	FY'79	FY'80	FY'81	FY'82
Full-Time Students	485	659	782	784	944
Part-Time Students	3,436	3,095	4,485	4,363	2,710
Continuing Education Trainees	1,683	6,421	8,944	9,853	11,252
Totals	5,604	10,175	14,211	15,000	14,906

B. Continuing Education - As mandated under the Occupational Safety and Health Act (Section 21), NIOSH conducts technical training courses for the Department, for other Federal, State, and local government agencies, and for the private sector, including occupational safety and health practitioners in industry, both management and labor representatives. In 1982, NIOSH presented a full range of catalog courses. In addition, customized courses were presented to the U.S. Navy, Coast Guard, State of New Jersey Health Department, State of Arizona Health Department, MSHA Training Academy, and Case Western Reserve University.

Vibration syndrome, video display terminals, manual lifting, and repetitive wrist motion (carpal tunnel syndrome) provided the major focus for the Institute's curriculum development activity for Fiscal Year 1982. On the subject of vibration syndrome, two videotapes were produced. The first, part of a NIOSH seminar series on epidemiologic studies of foundry workers at Nenah, Wisconsin, is directed toward the scientific community. The second program is aimed at the nontechnical audience and is designed to increase their awareness of the problem and to promote a better understanding of the causes of the disease.

Another recent research document produced by the Institute deals with the problems of manual lifting. Two videotapes were produced, one dealing with

the technical aspects and problems associated with lifting, the other taking a nontechnical approach. Both are useful tools in providing management and labor with information on methods to reduce the injuries associated with manual lifting.

To provide information about carpal tunnel syndrome, NIOSH produced a videotape that illustrates how modifications in procedures and equipment can have an impact on musculoskeletal problems of the wrist. It shows workers in a plant being analyzed as they perform various tasks and includes a comparison of old and new techniques of production. The three programs described above, as are all Institute training materials, are distributed through the 10 regional offices. In addition, copies are sent to the ERC's, where they are used as base resources for the continuing education and outreach program. In this way the Institute provides indirect assistance to professional societies, State health departments, and other educational centers.

The joint NIOSH/OSHA Industrial Arts Vocational Education training program completed the curriculum development and pilot testing phase. The course manual, consisting of 17 units dealing with safety and health hazards common in vocational school settings, has had wide dissemination, including Federal, State and local agencies, Federal and State correctional institutions, professional and trade associations, and various colleges and universities. NIOSH presented train-the-trainer instructional workshops to vocational education teachers, administrators and supervisors in six States: Arizona, California, Florida, Minnesota, New York, and Ohio. Instruction is given directly to vocational education teachers as a demonstration program, in the expectation that it can be extended by State and regional professional societies.

X. Policy Statements and Documents

A Criteria Document is the principal vehicle used for the formal transmittal of Institute recommendations to the Department of Labor (DOL) regarding workplace exposure to chemicals and other agents. NIOSH has also produced Criteria Documents that have addressed situations other than chemical exposures; the document on work in confined spaces is an example. Criteria Documents are of necessity comprehensive in their description and evaluation of all available information on a subject. The Criteria Document also is a means of disseminating NIOSH recommendations. In some instances, information becomes available to NIOSH that requires rapid dissemination to those responsible for occupational safety and health. Current Intelligence Bulletins notify those concerned of a specific emerging issue. Occupational Hazard Assessments, which are somewhat similar to Criteria Documents, contain recommendations for specific procedures to control hazards in the workplace, but are not necessarily directed at a single substance. Special Hazard Reviews are done to provide in-depth treatment of special problem areas, such as carcinogenicity. These documents are prepared in a format usable by a broad audience and not in the regulatory format of a Criteria Document. Recent Literature Reviews are designed only to present information and not to make recommendations nor to provide evaluations of the information.

During Fiscal Year 1982 recommendations, targeted at the 10 leading work-related illness and injury, have been formalized and disseminated on topics such as cobalt, sulfuric acid, and residential waste collection. Current efforts are directed at describing injury and illness in foundries, the paint and coatings industry, workers engaged in welding and brazing, and miners who may be exposed to asbestos, silica, or radon daughters. The Institute published 28 policy statements: one Criteria Document; three Current Intelligence Bulletins; 11 responses to regulatory actions of DOL; and 13 other types of documents aimed at assisting DOL in reducing health and safety hazards to workers. Current Intelligence Bulletins being developed address vibration syndrome, alkaline dusts, pentachlorophenol, and two of the many glycol ethers.

During Fiscal Year 1982 18,000 new documents were added to the NIOSHTIC data base. The NIOSHTIC system has been made internationally available on-line through DIALOG, the information retrieval system of Lockheed Information Systems. The Registry of Toxic Effects of Chemical Substances (RTECS) was increased by 6,000 new substances during Fiscal Year 1982 to include over 55,000 compounds. In addition, over 150,000 synonyms have been included as part of the RTECS file. The current awareness portion of the file was expanded to facilitate priority setting which also makes use of the data lines for primary skin and eye irritation, in vitro and in vivo mutation, reproductive effects, tumorigenicity, and acute toxicity.

XI. Superfund

During Fiscal Year 1982 NIOSH invested over 5 person-years of scientific and technical assistance in support of the Environmental Protection Agency's (EPA) Superfund program, which is mandated by the Comprehensive Environmental Response, Compensation, and Liability Act. The Institute's efforts included 1) writing and publishing a Worker Bulletin to aid hazardous waste workers in increasing their awareness of the potential hazards of their occupation, and to encourage them to seek training to avoid accidents and harmful exposure to hazardous substances, 2) significant progress towards writing a two-volume Comprehensive Guidance Manual to provide technical assistance for authorities and supervisors responsible for hazardous substance clean-up, and 3) continued research by technical staff on the possible hazards to workers posed by work practices at on-site disposal operations.

NIOSH, under a contract and an Interagency Agreement with the EPA, assembled a multidisciplined task force to study the hazardous waste program. Over 30 visits were made during Fiscal Year 1982 to 15 uncontrolled hazardous waste sites to determine the types of hazardous substances present and the levels to which workers are potentially exposed.

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